Technical Notes and Reviews

Attempts to Electrodeposit Zirconium

*M. L. Holt**

ABSTRACT

The work described was carried out with the hope of finding a definite answer, either positive or negative, to the question, "Can zirconium be electrodeposited from solution?" Attempts were made to electrodeposit zirconium and, in some cases, zirconium alloys from numerous aqueous and nonaqueous solutions. None of the solutions used gave a weighable electrodeposit of pure zirconium but some solutions gave thin cathode deposits which contained zirconium and iron. No work with fused salt baths for zirconium is included.

INTRODUCTION

Although a number of fused salt baths for the electrolytic production of zirconium have been proposed, only a few aqueous zirconium plating baths are described in the literature. In 1936 Bradt and Linford (1) reviewed previous work with aqueous zirconium plating solutions and proposed a new bath containing sodium and zirconyl sulfates. Laubengayer and Eaton (2) studied the reducibility of quadrivalent zirconium using polarographic and electrolytic experiments and suggested that high zirconium concentration and high *p*H favor the electrodeposition of zirconium. Kita, *et al.*, (3) reported their failure to obtain metallic zirconium by the electrolysis of aqueous solutions containing zirconium sulfate. Kroll and Schlechten (4) in their survey of the literature on the metallurgy of zirconium dismiss the subject of electroreduction of aqueous solutions with the statement, "Little hope can be seen for this method due to the great chemical activity of zirconium." A Japanese patent (5) makes the most recent claim for the successful electrodeposition of zirconium. So far as is known no organic or other nonaqueous plating solutions for zirconium have been reported except for the few mentioned by Laubengayer and Eaton (2).

EXPERIMENTAL

Ordinary electrolysis techniques were employed with a variable voltage rectifier supplying the direct current. Size of the electrolytic cells and area of the electrodes depended on the volume of plating solution being used. Most of the nonaqueous baths were used in a stoppered cell. In some cases plating solutions were agitated with a motor stirrer. Platinum or zirconium anodes and gold or copper cathodes were used and cathode current densities ranged from about 1 to 15 amp/dm^2.

No attempt was made to purify the chemicals used nor were the various nonaqueous solvents dried. The source of zirconium in the plating solutions was either C. P. zirconyl sulfate or high purity dense zirconium tetrachloride.

The presence or absence of zirconium in the cathode deposits was determined by precipitation of the phosphate from sulfuric acid solution (6).

Aqueous Solutions

Carbonate solutions.—The patented plating bath composed of zirconyl chloride and ammonium carbonate (5) is reported to give a film of zirconium on the cathode when electrolyzed at 8 to 20 amp/dm^2 at 27°C. This solution was checked thoroughly and found to give very thin cathode deposits containing iron and a trace of zirconium. For example, a solution containing 160 g/l of zirconium tetrachloride and 400 g/l of ammonium carbonate was electrolyzed at 15 amp/dm^2 for thirty minutes using a zirconium anode and a copper cathode. The resulting cathode deposit, which was dull but metallic in appearance, weighed only 2 mg; it dissolved readily in 6*M* nitric acid and gave an excellent test for iron and a slight test for zirconium.

Zirconium solutions containing an excess of sodium carbonate form a white precipitate when heated or electrolyzed; however, it was found that these solutions were stabilized somewhat by the addition of sodium citrate. Carbonate-citrate solutions prepared with high purity zirconium tetrachloride were colorless and gave no cathode deposit on electrolysis, whereas solutions prepared from zirconyl sulfate were a pale yellow and gave very thin metallic deposits containing iron and some zirconium.

Many of the cathode deposits obtained from the carbonate-citrate bath and from similar solutions were in part adherent blue-black spots or streaks and part silvery metal; the areas varied considerably but the black material usually covered about one third of the cathode. The cathode deposits from a series of electrolyses, having a total weight of 39.3 mg, showed by an approximate quantitative analysis the presence of about 5 per cent zirconium.

Since carbonate-citrate zirconium solutions gave cathode deposits which contained zirconium and iron, it seemed likely

* This work was done while the author was on a temporary appointment at the Argonne National Laboratory, Chicago, Illinois. Present address: Chemistry Department, University of Wisconsin, Madison, Wisconsin.

that other metals added to this solution would codeposit with zirconium. This was found to be the case with cobalt and zinc which were the only two tried. Electrolysis of carbonate-citrate zirconium solutions to which had been added small amounts of Zn^{++} or Co^{++} gave the same type of thin dark streaked or spotted metallic deposits. These deposits gave good qualitative tests for zirconium. The solution with added zinc seemed to have a greater tendency to form white oxide on the cathode surface than solutions with added iron or cobalt.

The Bradt and Linford bath (1).—When directions for preparing this bath were followed, considerable difficulty was experienced in getting an appreciable amount of zirconium in the bath and electrolysis of the resulting solution gave practically no cathode deposit. However, when an amount of zirconyl sulfate equivalent to the required amount of zirconium dioxide was used to prepare a bath, electrolysis resulted in a very thin silvery deposit on a gold cathode. This deposit disappeared as it was washed and dried.

Citrate and ammoniacal citrate solutions.—Previous experience with an ammoniacal citrate bath for the electrodeposition of other alloys (7) suggested that this type of solution might be useful for the electrodeposition of zirconium or especially for zirconium alloys. One of the solutions used was composed of 75 g/l of zirconyl sulfate, 75 g/l of citric acid, and ammonium hydroxide. Electrolysis at 10 amp/dm² at *p*H 1 and *p*H 4 gave very thin deposits on a gold cathode; these deposits faded when they were washed and dried. At *p*H 7 and *p*H 9 thin cathode deposits of iron were obtained.

Codeposition of zirconium with other metals was attempted with a bath containing 50 g/l of zirconyl sulfate, 100 g/l of citric acid, and ammonium hydroxide. Portions of this solution, 100 ml, to which had been added small amounts of various metal sulfates, were used. The current density was 5 amp/dm² and platinum anodes and a gold cathode were employed. There was no codeposition of zirconium, at bath *p*H values of 1, 5, and 9, with iron, cobalt, nickel, zinc, copper, or manganese. Similarly there was no codeposition with these metals from a solution containing 50 g/l of the metal sulfate, 10 g/l of zirconyl sulfate, and 100 g/l of citric acid using the same electrolysis conditions and bath *p*H values.

Sodium citrate-zirconyl sulfate solutions strongly acidified with various acids—sulfuric, hydrochloric, acetic, citric, oxalic or boric—were tried for deposition of zirconium and codeposition of zirconium and iron with negative results.

A German patent (8) claims the electrodeposition of titanium from a suspension of 16 g of titanium hydroxide in hot sodium hydroxide solution (75 g in 150 ml of water) at a cathode current density of 0.625 amp/dm². When zirconium hydroxide, or hydrated oxide, prepared from high purity zirconium tetrachloride, was substituted for titanium hydroxide, electrolysis for 1 hour at 0.6 amp/dm² gave a thin metallic cathode deposit which weighed less than 1 mg. This deposit gave a qualitative test for iron. When a small amount of Fe^{+++} was added to the bath, electrolysis for ½-hour gave a dull metallic deposit weighing about 2 mg. This deposit gave an excellent test for iron and a fair test for zirconium.

Another plating bath for titanium contains an excess of the hydroxide in 8 per cent aqueous sulfanilic acid (9). Electrolysis at 15°–20°C and 0.1 to 0.15 amp/dm² is claimed to give a thin deposit of titanium. Electrolysis of this type of bath, with zirconium hydroxide substituted for titanium hydroxide, gave no indication of a cathode deposit.

Other aqueous solutions.—A number of other aqueous solutions were tried without succeeding in electroplating zirconium. Solutions of zirconyl sulfate in aqueous fluoboric acid, boric acid, oxalic acid, tartaric acid, and trisodium phosphate were among those used. Only the trisodium phosphate-zirconyl sulfate solution gave a cathode deposit and this was found to be iron. The mixed ammonium acetate-potassium acetate-molybdenum plating bath (10) with zirconium oxide substituted for molybdic oxide was also tried. It foamed a great deal during electrolysis and gave no cathode deposit. An aqueous solution of urea and zirconium tetrachloride, when electrolyzed at about 2.5 amp/dm², gave an extremely thin metallic-appearing deposit which disappeared as it was washed and dried.

Nonaqueous Solutions

Aluminum plating baths modified for zirconium.—The Blue and Mathers aluminum plating bath (11) is composed of aluminum chloride and bromide, benzene, xylene, and ethyl bromide. A similar bath, using zirconium chloride and bromide instead of the corresponding aluminum salts, failed to give an electrodeposit of zirconium. The zirconium salts had a very limited solubility in benzene and xylene and there appeared to be no separation into layers when the ethyl bromide was added.

One of the Hurley and Wier baths for plating aluminum (12) is a melt of ethylpyridinium bromide and aluminum chloride which is dissolved in benzene. A mixture of zirconium tetrachloride and ethylpyridinium bromide was found to require a fairly high temperature to give a clear melt; it was a poor conductor and gave some dark gummy residue on the cathode. The solidified melt was apparently insoluble in benzene and since no satisfactory solvent was found, it was concluded that this mixture was unsuitable for the electrodeposition of zirconium.

Organic nitrogen derivatives.—Zirconium tetrachloride was used with ethanolamine, triethanolamine, diethylamine, triethylamine, ethylenediamine, analine, pyridine, quinoline, phenylhydrazine, piperidine, and acetonitrile. In some cases there was a reaction, in some cases the solubility was very slight, but in no case was an electrodeposit of zirconium obtained.

Formamide has been suggested for the electrodeposition of metals and alloys (13) and it was tried for zirconium. Zirconium tetrachloride was found to be soluble in melted formamide; the melt was a good conductor but on electrolysis there was no cathode deposit. When small amounts of Fe^{++}, Ni^{++}, or Co^{++} were added to the melt, electrolysis gave very thin dark cathode deposits which contained zirconium and the added metal. Zirconium tetrachloride was also found to be soluble in molten propionamide and acetamide but no electrodeposit of zirconium was obtained.

Other nonaqueous reagents.—Zirconium tetrachloride was added to the following organic compounds: ethyl, isobutyl and isoamyl alcohols, formic and acetic acids, benzene, chloro- and bromobenzene, glycerine, ethylene glycol, isoamyl acetate, ether, chloroform, hexachloropropylene, and acetylacetone. In some cases solubility and conductance were good, particularly with ethyl alcohol, ethylene glycol, and acetic acid, but in no case was there an electrodeposit of zirconium. Zirconium tetrachloride seemed fairly soluble in phosphorus oxychloride but the solution or reaction product was a nonconductor. The tetrachloride appeared insoluble in phosphorus trichloride.

Liquid ammonia.—Zirconium tetrachloride seemed slightly soluble in liquid ammonia and on electrolysis of the solution a very thin dark nonmetallic cathode deposit was obtained; this gave a definite qualitative test for zirconium.

CONCLUSIONS

No weighable cathode deposit of pure zirconium was obtained from any of the numerous aqueous and nonaqueous solutions which were tried. In a few cases very thin, shiny, metallic appearing deposits were obtained; these deposits were observed to fade or oxidize a few seconds after they were taken out of the plating solution. Weighable cathode deposits containing zirconium and iron were obtained from a few solutions.

When the activity of zirconium is considered, it is not surprising that the metal has not been electrodeposited from aqueous solution. Its calculated potential, $E°$ (14), is close to the potentials of aluminum and beryllium, neither of which has been electrodeposited from aqueous solution.

Organic solutions should perhaps offer some promise for the electrodeposition of zirconium since aluminum has been deposited from several different organic plating baths. However no electrodeposited zirconium was obtained from solutions of the same type as the aluminum plating baths. It is doubtful that an organic bath, if developed, would be useful for the production or electrodeposition of zirconium.

ACKNOWLEDGMENT

The writer wishes to express his appreciation to the members of the Metallurgy Division of the Argonne National Laboratory for their cooperation during the progress of this work. He also wishes to thank Dr. W. J. Kroll, of the U. S. Bureau of Mines, for supplying the high purity zirconium tetrachloride which was used in much of this work.

REFERENCES

1. W. E. Bradt and H. B. Linford, *Trans. Electrochem. Soc.*, **70,** 431 (1936).
2. A. W. Laubengayer and R. B. Eaton, *J. Am. Chem. Soc.*, **62,** 2704 (1940).
3. T. Kita, et al., *Bull. Inst. Phys. Chem. Research (Tokyo)*, **23,** 239 (1944); *C. A.* **42,** 6673 (1948).
4. W. J. Kroll and A. W. Schlechten, *U. S. Bur. Mines Inform. Circ.* No. 7341 (1946).
5. K. Koizumi, et al., Japanese Pat. 172,621, May 9, 1946; *C. A.*, **43,** 6925 (1949); Brutcher Translation No. 2509.
6. W. W. Scott, "Standard Method of Chemical Analysis," 5th ed., Vol. **1,** p. 1093, D. Van Nostrand Co., Inc., New York (1939).
7. H. J. Seim and M. L. Holt, *J. (and Trans.) Electrochem. Soc.*, **96,** 205 (1949).
8. E. Pokorny, German Pat. 605,551, Nov. 13, 1934.
9. N. N. Gratsianski and A. P. Vovkogon, *Zapiski Inst. Khim. Akad. Nauk U. R. S. R.*, **7,** 173 (1940); *C. A.*, **35,** 3503 (1941); Brutcher Translation No. 2183.
10. M. J. Ksycki and L. F. Yntema, *J. (and Trans.) Electrochem. Soc.*, **96,** 48 (1949).
11. R. D. Blue and F. C. Mathers, *Trans. Electrochem. Soc.*, **65,** 339 (1934); **69,** 519, 529 (1936); *Metal Cleaning Finishing*, **10,** 114 (1938).
12. F. H. Hurley and T. P. Wier, U. S. Pat. 2,446,331; 2,446,349; 2,446,350, Aug. 3, 1948.
13. R. D. Blue and F. C. Mathers, *Trans. Electrochem. Soc.*, **63,** 231 (1933).
14. W. M. Latimer, "The Oxidation States of the Elements and their Potentials in Aqueous Solutions," p. 252, Prentice-Hall, Inc., New York, (1938).

Review of Articles on Luminescence for 1950*

Gorton R. Fonda†

NEW PHOSPHORS

The development of such phosphors as the magnesium fluogermanate just discovered by Thorington (1) offers encouragement to the pursuit of experimental science, for it illustrates how a specific property of a substance may be magnified in an unforeseen manner by appropriate alteration in the constitution of that substance. Williams had increased the brightness of Mg_2GeO_4:Mn fivefold by preparing it with excess MgO to form Mg_4GeO_6:Mn. By replacing part of the MgO with MgF_2, Thorington is able to double the brightness under 2537 Å. Another notable feature is that the maximum brightness under 3650 Å excitation occurs at 330°C.

Another instance of the unexpected influence of constitution is given by the barium magnesium silicates activated with lead, described by Butler and Cassanos (2). Distinct crystal structures are found to characterize the two best phosphors. A mesotrisilicate has an emission similar to that of $MgWO_4$. A near metasilicate emits at different shades of blue-green, depending upon the relative content of BaO and MgO.

Guenther, Anderson, and Perlitz (3) describe modifications produced by CaF_2 in alumina phosphors activated by manganese. Excited by 2537 Å and 3650 Å, their luminescence is made up of two bands in the red and infrared; under cathode rays, the fluorescence color depends upon composition and firing temperature.

In calcium zinc phosphate activated with thallium, Nagy, Wollentin, and Lui (4) find that the addition of zinc oxide lowers the emission peak from 3280 Å to 3115 Å.

Two papers deal with the halides. Bose and Sharma (5) describe the luminescence of the pure alkali halides when excited by cathode rays at low temperature. Some of these halides were studied under cathode-ray excitation, when activated by thallium, manganese, copper, uranium, silver, beryllium, and lead. Farnell, Burton, and Hallaws (6) have studied the emission spectra of mixed crystals of the silver halides and point out how the effects of change in temperature are compatible with the predictions derived from a configurational coordinate diagram.

A preliminary description is given by Lyon and Poore (7) of some new infrared sensitive phosphors of low infrared stimulability, prepared from oxide bases and activated with the pairs Mn-Sm, Ce-Sm, and Pb-Cu. Bersis (8) has studied the prolonged phosphorescence that characterizes infrared-sensitive strontium sulfides activated with Zn-Bi and Zn-Sm.

Smith (9) deals with phosphors prepared from silicates of calcium with a second element, magnesium or beryllium, and describes their preparation and luminescence under cathode-ray

* A "Review of Articles on Luminescence for 1949" appeared in the January 1950 Journal, page 3C.

† 1028 Parkwood Boulevard, Schenectay, New York.

excitation. $CaO \cdot MgO \cdot 2SiO_2$:Ti is an efficient blue-emitting phosphor; activation with cerium gives emission in the ultraviolet. $CaO \cdot BeO \cdot SiO_2$:Mn emits strongly in the orange.

PHOSPHOR CHARACTERISTICS

Calcium halophosphates.—These phosphors exhibit apatite structure. Their preparation from mixtures of acid phosphate, calcium carbonate, and calcium halides, to which activators of antimony and manganese have been added, entails a complex reaction. Among the minor reactions are those involving antimony. Butler, Bergin, and Hannaford (10) describe the formation of three antimony compounds and discuss the further reactions which these compounds undergo in the introduction of antimony to the luminescence center. The dependence of the emission spectra of the resulting phosphors upon composition is given an extensive treatment by Butler and Jerome (11). They show how the antimony and manganese emission bands may be analysed into subsidiary ones having Gaussian distribution and endeavor to assign them to specific energy levels of the excited ions and to interpret their relation to the crystal structure.

Emission of silicate phosphors.—In 1949 several authors presented the hypothesis that the green fluorescence band in zinc silicate could be broken up into five component bands. Another step has now been taken in an attempt to discriminate between these bands by noting whether they exhibit different decay rates of phosphorescence. Gergely (12) has measured the decay under varying periods of cathode-ray excitation and finds that both the induction and the decay may be separated into three component rates. The decay of each is strictly monomolecular, with time constants of 200, 1800, and 72,000 sec^{-1}. The fast component is predominant under very short excitation, and the slow under prolonged excitation. E. Nagy (13) has extended these observations by examining the emission spectra. Preliminary measurements make it probable that the shortest decay lies in the blue, that the yellow sub-bands have the decay constant of 2000 and that the main band at 5250 Å has the slowest rate. The phosphorescence spectrum, as measured 2–5 milliseconds after excitation, was symmetrical.

Klick and Schulman (14) have made similar measurements on this phosphor, exciting with 2537 Å, however; their spectra of phosphorescence are identical with the fluorescence spectrum. They have also measured the emission spectrum in liquid helium and find only a single band (15), with no evidence of line emission.

There is also disagreement in regard to the spectral character of phosphorescence from zinc beryllium silicate. In contrast to previous measurements, Schulman, Klick, and Ginther (16) find pronounced differences, denoting that the green band decays more rapidly than the red, a more reasonable supposition.

They have also measured the emission of lead-activated calcium silicate (17), together with the absorption and excitation spectra. For lead alone they get two sets of characteristics which they ascribe to differences in lead content rather than in structure. They ascribe the sensitization of manganese emission to an interaction of divalent lead ions with those divalent manganese ions which are situated in the first two neighboring rings of cation sites around a lead ion.

Changes in emission characteristics due to temperature.—Kroeger and his co-workers have been giving attention to the mechanism that may underlie the temperature quenching of fluorescence. A general discussion, including a theoretical treatment, is given by Kroeger and de Groot (18) of the dissipative processes which tend to quench fluorescence and of the methods used for measuring efficiency and decay. Kroeger and Hoogenstraaten (19) decide that if a system is excited directly to the state from which the fluorescence transition takes place, then the quenching of fluorescence is accompanied by an increase in the rate of decay at the same critical temperature, as illustrated by data on the borate and silicate of cadmium. Similar evidence is presented by Kroeger and Boomgaard (20) for magnesium germanate, activated with manganese. For $4MgO \cdot GeO_2$:0.01Mn, related to Thorington's new phosphor (1), they find seven narrow sub-bands and ascribe them to tetravalent manganese. The group of the three weaker bands increases in intensity with temperature rise. The group of four stronger bands remains constant in intensity and in decay rate up to 600°C; thereafter, the fluorescence falls abruptly and the decay rate rises abruptly.

In oxygen-dominant phosphors, Fonda (21) finds that the shorter band in duplex band emission becomes predominant on increase in temperature as well as on decrease in activator content. In phosphors whose spectral emission is not changed by a change in activator content, the band is shifted to shorter wavelength by increase in temperature.

Jones (22) has produced a permanent shift in the fluorescence spectrum of zinc beryllium silicate to the green by refiring at 800°–1200°C and quenching. The extent of the shift becomes greater as the temperature of refiring is increased.

Sulfide phosphors.—Kroeger and his co-workers are still giving attention to the role which auxiliary elements play in the functioning of activators in zinc sulfide. In recent papers they consider more particularly the matter of valency. Kroeger, Hellingman, and Smit (23) demonstrate that green copper centers are formed when copper is incorporated in the sulfide as CuCl, whereas blue Cu centers result when the copper is present as $CuCl \cdot Cu$. Blue zinc centers, on the other hand, come into existence by incorporation of chlorine and the reduction of divalent zinc to monovalent, forming ZnCl.

Although chlorine is regarded as an essential type of element in the incorporation and functioning of the activator, Kroeger and Dikhoff (24) believe that it does not belong to the center proper, which consists of monovalent ions of Cu or of Zn or of divalent ions of Cu, surrounded by sulfur ions. When a monovalent cation is built into a lattice of divalent ions, the valency requirements may be met by substitution either of a monovalent Cl ion for sulfur or of a trivalent cation for zinc, in the absence of chlorine. The most effective of the latter is aluminum. A detailed discussion is given by Kroeger and Smit (25) of the reactions and chemical equilibria that exist between the solid and gas phases in the formation of centers by incorporation of chlorine; the dependence of the composition on atmosphere of firing is treated quantitatively.

Larach (26) has furnished some new data on the poisoning of cubic ZnS:Ag by cobalt, iron, and nickel, under cathode-ray excitation.

Several papers deal with infrared-sensitive phosphors. Four of them are further contributions from the laboratory of Roland Ward. One, by Banks and Ward (27), is a study of solid solutions of Ce_2S_3 in strontium sulfide. They conclude that the cerium enters the SrS lattice in the trivalent state and in substitutional positions. The second paper, by Yakel, Banks, and Ward (28), shows that the sulfides of the rare earths, lanthanum, cerium, praseodymium, neodymium, samarium, and gadolinium, are appreciably soluble in strontium sulfide. They appear as trivalent ions, two of them replacing

three strontium ions in the sulfide lattice. Melamed (29) finds that the quenching bands in zinc sulfide are the same for the four activator pairs, Mn-Cu, Fe-Cu, Ni-Cu, and Co-Cu. He concludes, therefore, that they are to be attributed to copper as the auxiliary activator. These quenching bands are the same as the stimulation bands for the pairs Pb-Cu and Mn-Cu. The conclusion that quenching and stimulation proceed from the same process is in accord with Urbach's theory. Measurements of photoconduction and of quenching by cadmium sulfide indicate that the quenching bands are due to both deep and shallow traps associated with the auxiliary activator. Banks, Russo, and Ward (30) have made a fresh attempt to prepare brighter infrared-sensitive phosphors of magnesium sulfide. The brightest was obtained with the activator pair Ce-Sm with a peak at 4925 Å. Its brightness was less than one tenth that obtained with the same activators in strontium sulfide.

Brauer (31) presents an explanation for the inertia effects exhibited by strontium sulfide and selenide phosphors in the development of stimulated luminescence. He contends that two steps are involved; a rapid transition from a deep trap associated with the auxiliary activator and slow transitions from phosphorescence traps.

Roberts and Williams (32) present a theoretical discussion for the operation of super-linear phosphors. They consider that the transition responsible for light emission lies between the ground state of the activator atom and a metastable state, located below the conductivity band. The extent of emission depends upon the relative rates of capture of electrons by this state, traps, and empty killer centers. Their equations agree with Urbach's observations for a zinc cadmium sulfide activated with silver and nickel.

Three other papers have appeared on this subject. Urbach, Nail, and Pearlman (33) describe the spectacular use of superlinear or nonlinear phosphors as thermometric substances, dependent upon their change in properties at a critical temperature. The heated object may be coated with a phosphor so as to render its temperature distribution visible as a pattern of varying brightness or color; or the phosphor may be coated on a screen to record visually an image of the heated object. The second paper is by Garlick and Gibson (34) and contains a review of experiments on nonlinear phosphors, followed by new experiments on the dependence of luminescence efficiency upon temperature and upon excitation intensity, with particular attention to the photoconductivity and semiconduction developed within the critical temperature range. The observations show that at elevated temperatures these phosphors behave as excess semiconductors. The third paper, by Hill and Klasens (35), deals with the temperature dependence of fluorescence from ZnS:Ag:Ni within the range 120°–600°K. The results are interpreted in terms of the theory of hole migration.

Miscellaneous.—Several papers describe unusual aspects of phosphors. Frerichs (36), for instance, reviews observations on those crystals which yield pulses under irradiation with nuclear particles or gamma rays, and concludes that they belong to the class of crystal phosphors, in that they show such characteristics as luminescence under radiation in an absorption band, a power law decay, and photocurrents. Such substances are cadmium and zinc sulfides, silver and thallium chlorides, and silver bromide.

The efficiency of zinc oxide phosphors under cathode-ray excitation is, according to Larach (37), affected by washing the phosphor powder in solutions of electrolytes. With sodium hydroxide, the brightness was increased 11 per cent. The effect is ascribed to perturbing action on atomic layers near crystal surfaces. The source of luminescence in this phosphor is believed by Thomsen (38) to be due to the presence of a small amount of sulfide rather than of free zinc, for it is formed by firing the oxide in a closed vessel with a little sulfide. When the preparation was carried out by adding the selenide instead of the sulfide, the luminescence color changed from green to orange.

Crawford and Williams (39) have studied electronic processes in zinc fluoride, as an *N*-type impurity semiconductor. The conductivity is materially decreased when manganese is added to form the phosphor.

The Millsons (40) have recorded the phosphorescence of minerals, both visually and photographically.

Bril and Kroeger (41) discuss the merits of silicate phosphors for television tubes at such large current densities that their saturation current is higher than is characteristic for the sulfides.

Payne, Mayer, and Jerome (42) have experimented on the phenomenon of electroluminescence, associated with the work of Destriau. In contrast to Leverenz, they have obtained favorable light outputs by coating the conducting surface of a glass plate with a layer of phosphor, covering the phosphor with a metal foil, and applying high frequency at moderate voltage between the glass and the foil. They studied the relation between the light output and the electrical characteristics of the circuit.

Stericker and Hazel (43) discuss further the improved adherence of phosphors to glass that results from adding sodium sulfate to the potassium silicate binder. They ascribe its action to a polymerization of silicate radicals through the formation of oxygen bridges.

Recording spectrophotometers designed for measuring the emission of phosphors and of luminescent devices have been described by Studer and Jacobson (44) and by Parsons, Martin, and Roberto (45).

BIBLIOGRAPHY

1. L. Thorington, *J. Optical Soc. Am.*, **40,** 579 (1950).
2. K. H. Butler and J. G. Cassanos, *J. Electrochem. Soc.*, **97,** 83 (1950).
3. G. Guenther, G. Anderson, and H. Perlitz, *Arkiv Kemi*, **1,** 565 (1950); *C. A.*, **44,** 7152 (1950).
4. R. Nagy, R. W. Wollentin, and C. K. Lui, *J. Electrochem. Soc.*, **97,** 29 (1950).
5. H. N. Bose and J. Sharma, *Proc. Natl. Inst. Sci. India*, **16,** 47, (1950).
6. G. C. Farnell, P. C. Burton, and R. Hallaws, *Phil. Mag.*, **41** 545 (1950).
7. D. W. Lyon and E. L. Poore, *J. Optical Soc. Am.*, **40,** 179 (1950).
8. D. S. Bersis, *J. Optical Soc. Am.*, **40,** 335 (1950).
9. A. L. Smith, *J. Electrochem. Soc.*, **96,** 287 (1949).
10. K. H. Butler, M. J. Bergin, and V. M. B. Hannaford, *J. Electrochem. Soc.*, **97,** 117 (1950).
11. K. H. Butler and C. W. Jerome, *J. Electrochem. Soc.*, **97,** 265 (1950).
12. G. Gergely, *J. Optical Soc. Am.*, **40,** 356 (1950).
13. E. Nagy, *J. Optical Soc. Am.*, **40,** 407 (1950).
14. C. C. Klick and J. H. Schulman, *J. Optical Soc. Am.*, **40,** 509 (1950).
15. J. H. Schulman and C. C. Klick, *J. Optical Soc. Am.*, **40,** 622 (1950).
16. J. H. Schulman, C. C. Klick, and R. J. Ginther, *J. Optical Soc. Am.*, **40,** 337 (1950).
17. J. H. Schulman, R. J. Ginther, and C. C. Klick, *J. Electrochem. Soc.*, **97,** 123 (1950).

18. F. A. Kroeger and W. de Groot, *Philips Tech. Rev.*, **12**, 6 (1950).
19. F. A. Kroeger and W. Hoogenstraaten, *Physica*, **16**, 30 (1950).
20. F. A. Kroeger and J. van den Boomgaard, *J. Electrochem. Soc.*, **97**, 377 (1950).
21. G. R. Fonda, *J. Optical Soc. Am.*, **40**, 347 (1950).
22. S. Jones, *J. Electrochem. Soc.*, **97**, 25 (1950).
23. F. A. Kroeger, J. E. Hellingman, and N. W. Smit, *Physica*, **15**, 990 (1949).
24. F. A. Kroeger and J. Dikhoff, *Physica*, **16**, 297 (1950).
25. F. A. Kroeger and N. W. Smit, *Physica*, **16**, 317 (1950).
26. S. Larach, *J. Chem. Phys.*, **18**, 896 (1950).
27. E. Banks and R. Ward, *J. Electrochem. Soc.*, **96**, 297 (1950).
28. H. L. Yakel, E. Banks, and R. Ward, *J. Electrochem. Soc.*, **96**, 304 (1950).
29. N. T. Melamed, *J. Electrochem. Soc.*, **97**, 33 (1950).
30. E. Banks, V. J. Russo, and R. Ward, *J. Am. Chem. Soc.*, **72**, 3173 (1950).
31. P. Brauer, *J. Optical Soc. Am.*, **40**, 353 (1950).
32. S. Roberts and F. E. Williams, *J. Optical Soc. Am.*, **40**, 516 (1950).
33. F. Urbach, N. R. Nail, and D. Pearlman, *J. Optical Soc. Am.*, **39**, 1011 (1949).
34. G. F. J. Garlick and A. F. Gibson, *J. Optical Soc. Am.*, **39**, 935 (1949).
35. C. G. A. Hill and H. A. Klasens, *J. Electrochem. Soc.*, **96**, 275 (1950).
36. R. Frerichs, *J. Optical Soc. Am.*, **40**, 219 (1950).
37. S. Larach, *J. Phys. & Colloid Chem.*, **54**, 467 (1950).
38. S. M. Thomsen, *J. Chem. Phys.*, **18**, 770 (1950).
39. J. H. Crawford and F. E. Williams, *J. Chem. Phys.*, **18**, 775 (1950).
40. H. E. Millson and H. E. Millson, Jr., *J. Optical Soc. Am.*, **40**, 430 (1950).
41. A. Bril and F. A. Kroeger, *Philips Tech. Rev.*, **12**, 120 (1950).
42. E. C. Payne, E. C. Mayer, and C. W. Jerome, *Illum. Eng.*, **45**, 688 (1950).
43. W. Stericker and F. Hazel, *J. Phys. & Colloid Chem.*, **54**, 1045 (1950).
44. F. J. Studer and W. R. Jacobson, *Gen. Elec. Rev.*, **53**, No. 10, 34 (1949).
45. S. L. Parsons, A. E. Martin, and S. N. Roberto, *J. Electrochem. Soc.*, **97**, 41 (1950).

FUTURE MEETINGS OF

The Electrochemical Society

Washington, D. C., April 8, 9, 10, 11, and 12, 1951

Sessions on

Electrothermics, Electric Insulation, Luminescence,

Rare Metals, and Theoretical Electrochemistry

Round Table on Industrial Electrolytics

Headquarters at the Wardman Park Hotel

* * *

Detroit, October 10, 11, 12, and 13, 1951

Sessions on

Corrosion, Electrodeposition, Electro-Organic Chemistry

Round Table on Electrothermics

Headquarters at the Statler Hotel

* * *

Philadelphia, Spring, 1952

* * *

Montreal, Fall, 1952

Current Affairs

Record Number of Papers for Washington

Members are urged to make plans now for attending the 99th General Meeting of the Society, to be held Sunday through Thursday, April 8th–12th, at the Wardman Park Hotel in Washington, D. C.

Of special interest will be the record-breaking number of papers, over 120, which have been scheduled for the symposia to be sponsored by the Electric Insulation, Electronics, Electrothermic, and Theoretical Divisions. As an added feature to the technical program, a round-table discussion will be sponsored by the Industrial Electrolytic Division. The complete schedule of technical papers will be printed in the April issue of the JOURNAL.

Special attention is called to the fact that the Convention will begin on Sunday, rather than on Wednesday as has been the custom in the past. Committee meetings will be held Sunday morning, and the Board of Directors will meet Sunday afternoon. Technical sessions will begin Monday morning.. Because of the numerous places of interest to visit in Washington, many persons may prefer to arrive on Saturday or before. Everyone is urged to make hotel reservations early.

Highlighting the nontechnical part of the program will be the Annual Banquet, to be held Tuesday evening, April 10th. The principal speaker at this time will be Society President Charles L. Faust. Another feature of the banquet will be the annual awards of the Young Author's Prize and the Turner Book Prize. A reception honoring President and Mrs. Faust will precede the banquet.

The schedule for Monday, April 9th, will include the annual business meeting which will take place immediately following a Society luncheon. Evening plans include a buffet supper and entertainment planned by the Local Committee. Luncheons on Tuesday, Wednesday, and Thursday will be sponsored by the various Divisions.

In view of the fact that Washington is not an industrial center, an extensive plant-visit program has not been arranged. However, members will find much of interest in visits to the National Bureau of Standards, which is celebrating the semicentennial of its founding. Trips will be arranged for 1.30 P.M. daily.

THE JEFFERSON MEMORIAL, A FINE EXAMPLE OF THE CLASSICAL ARCHITECTURE SEEN IN MANY OF WASHINGTON'S BUILDINGS

The Ladies' Commtitee, with Mrs. Paul L. Howard as Chairman and Mrs. William Blum as Honorary Chairman, is planning an interesting program for the wives who will be taking advantage of this opportunity to visit Washington. At this writing, the agenda includes a complimentary tea, a complimentary luncheon, and a tour to points of interest in Washington.

Whitaker Awarded Chandler Medal for 1950

Milton C. Whitaker, founder of Columbia University's Department of Chemical Engineering, was awarded the University's Chandler Medal for 1950 in recognition of his outstanding achievements in the chemical industry. The award was made on January 16th, at Havemeyer Hall, by Dr. Grayson L. Kirk, acting head of the University.

Mr. Whitaker was first connected with Columbia in 1898 as a private assistant to Professor Charles F. Chandler, founder of the Chandler Medal. He later became professor of chemical engineering and in 1913 organized the department. Resigning from Columbia in 1916, Mr. Whitaker joined U. S. Industrial Alcohol Company and later became vice-president and director of American Cyanamid Company, remaining there until his retirement in 1947. He was a member of The Electrochemical Society for many years.

ISA-Carnegie Tech Conference, March 28-29

The Pittsburgh Section of the Instrument Society of America, jointly with Carnegie Institute of Technology, will sponsor a conference, March 28th and 29th, on "Instrumentation in the Steel Industry." The meetings will be held at

Carnegie Tech, in Pittsburgh. Pittsburgh Local Sections of the following societies are cooperating: American Institute of Electrical Engineers, American Institute of Mining & Metallurgical Engineers, American Society for Metals, American Society of Mechanical Engineers, American Society for Testing Materials, American Welding Society, Association of Iron & Steel Engineers, and the Engineers Society of Western Pennsylvania.

Prize Essay Contest

Announcement has been made of The Electrochemical Society Prize Essay Contest. Two prizes will be awarded for the best undergraduate essays on the subject of "Cathodic Protection." First prize will be $100 plus a one-year membership in the Society; second prize will be $50, together with a one-year Society membership. Essays, 1000 to 2000 words, must be received by July 1, 1951. Winners will be announced in the October 1951 issue of the JOURNAL.

Financial support for the prizes will come from the royalties received from the sale of the "Corrosion Handbook," a highly successful volume sponsored by the Society and published by John Wiley & Sons, Inc., in 1948 (see June 1950 JOURNAL, page 126C).

Additional information concerning the awards may be obtained by writing to the Secretary of The Electrochemical Society, 235 West 102nd Street, New York 25, New York.

Centennial for Corning

Corning Glass Works will commemorate its one hundredth anniversary in 1951, according to an announcement by Amory Houghton, its Board Chairman.

Mr. Houghton emphasized the wide use of glass by man, and stressed the industry's great developments in recent years. Some of Corning's outstanding achievements have been the first practical bulb for Edison's electric lamp, development of Pyrex brand heat-resistant glass, casting of the 200-inch telescope disc, and mass production of glass for television picture tubes.

The company was founded as the Union Glass Company in Somerville, Massachusetts, in 1851, by Amory Houghton, great-grandfather of the present Chairman. It moved to Brooklyn in 1864 and, four years later, was transferred to Corning, New York. Today, not including its subsidiaries, Corning Glass Works employs over 8,000 residents in that area and over 4,000 in other cities.

DIVISION NEWS

Electrothermic Division

New by-laws for the Electrothermic Division were approved by the Board of Directors on December 2, 1950. These by-laws were drawn up by a Divisional committee, consisting of C. H. Chappell, A. T. Hinckley, and M. Udy, to correct inconsistencies and more fully define the functions of the Division. The important changes and additions include a statement of purpose; election of officers and members-at-large for two years, instead of one; more satisfactory procedures for nominating, electing, and replacing the officers and members-at-large; more explicit definitions of duties of officers; methods for handling Divisional funds; and stipulations as to the business and technical meetings.

The members of the Division will pass on these new by-laws at its annual business meeting, to be held in Washington during the regular Spring 1951 meeting of the Society. Mimeographed copies of the entire by-laws may be obtained by writing to the Secretary, The Electrochemical Society, 235 West 102nd Street, New York 25, N. Y.

JULIAN GLASSER, *Chairman*

SECTION NEWS

Cleveland Section

The Cleveland Section met on January 9th at the Cleveland Engineering Society. After a social hour and dinner the guest speaker, Dr. H. M. Scholberg, of the Minnesota Mining & Manufacturing Company, gave an interesting talk on "Electrochemical Fluorination."

Dr. Scholberg described the cell for the production of fluocarbons and discussed the large number of fluocarbon compounds possible, as many as 100,000. He gave some possible applications as follows:

1. Nonwetting fabrics
2. Catalysts
3. Electrical insulation
4. Foam inhibitors
5. Rubber: makes rubber snappy at −125°C
6. Lubrication: possible life-time lubrication in sealed motors.

L. E. PUCHER, *Secretary*

(Dr. Scholberg addressed the Philadelphia Section on the subject of "Fluocarbons" on the following evening and a summary of his talk appears under the Philadelphia Section news.)

Midland Section

"Titanium—A New Structural Metal" was the topic chosen by W. J. Barth of E. I. du Pont de Nemours & Company, Inc., for his address before the Midland Section on January 10th at the Dow Auditorium, Midland. Movies were shown immediately previous to the meeting and a dinner was held at the Midland Country Club.

A brief summary of points covered in Mr. Barth's talk follows:

Ductile titanium is still an experimental metal, there being no large-scale proven uses.

To produce a ductile metal, titanium must be free of oxides and nitrides. A commercial process involves reduction of titanium trichloride with magnesium at approximately 1000°C. Graphite is the most suitable refractory, although not completely satisfactory.

Arc and induction type furnaces have been used, arc furnaces producing a purer titanium. Ingots up to 650 pounds have been cast.

Titanium is resistant to moist chlorine, but burns in dry chlorine. Specimens at Kure Beach showed phenomenal resistance to corrosion in sea-water—comparable to Hastelloy. Titanium is not satisfactory for use at temperatures above 300°C. Titanium-manganese alloys show promise for higher temperatures.

Titanium's future rests on its ease of fabrication. It can be fabricated on conventional steel mill equipment. It is also easily spot or arc welded.

During the discussion period which followed, other points about titanium were brought out, e.g., (*a*) the metal showed resistance to stress corrosion, (*b*) oxygen content for ductility must be below 0.2 per cent, (*c*) nonductile titanium cannot be purified.

H. H. ROTH, *Secretary-Treasurer*

New York Metropolitan Section

Attendance at the Metropolitan Section meetings has been improving gradually and at the meeting on January 17th, at the Holley Hotel, there was an unusually large turnout to hear Dr. R. B. Mears, of the Research Laboratory of the United States Steel Company (formerly Carnegie-Illinois Steel Corporation).

Dr. Mears discussed "Passivity and Inhibition," a subject on which he is an outstanding authority. After a short

historical introduction, he stressed the controversial nature of the subject of passivity, citing two rival definitions. The various mechanisms which have been proposed, such as the film theory and the electron configuration theory, were reviewed but neither of these, Dr. Mears said, is entirely satisfactory. The film theory is of service when used for explaining passivity but is useless for prediction; and while the electron configuration mechanism gives promise of having predictive possibilities, some of these predictions are not borne out in practice. In this connection, the speaker mentioned the anomalous behavior of chromium-iron alloys.

Dr. Mears then proceeded to an exposition of the local cell theory of corrosion and passivity wherein passivity is promoted by increasing the polarization of the local anodes or cathodes, or both. The general outlines of this phase of Dr. Mears's work are no doubt familiar to many readers of this JOURNAL, so no attempt will be made to summarize them here.

Discussion of the topic was very animated and continued until the chairman had to call an adjournment because of the late hour.

The Metropolitan Section has expanded its activities this year, scheduling a larger number of meetings, and it is also planning an innovation—Ladies' Night—for the last meeting of the year.

F. A. LOWENHEIM, *Secretary-Treasurer*

Philadelphia Section

The Philadelphia Section held its second meeting of the current season on January 10th in the Harrison Laboratory, University of Pennsylvania. A dinner in honor of the speaker, Dr. H. M. Scholberg, of the Minnesota Mining & Manufacturing Company, preceded the meeting.

Dr. Scholberg spoke on the subject of "Fluocarbons." After commenting on their electrolytic production he outlined some of the principal properties of that class of compounds, particularly as compared with the same properties of the corresponding hydrocarbon compounds. He indicated the great advancement in the field since the pioneering work of Professor Simons at Pennsylvania State College thirteen years ago.

With regard to the preparation of fluocarbons by electrolysis, the speaker outlined the requisites of an ideal commercial electrochemical process, and showed that electrofluorination of hydrocarbons was a process meeting these requirements. The products are easily separated, the desired constituents being largely insoluble in anhydrous hydrogen fluoride; a small cell is satisfactory, since no diaphragm is needed; the process is continuous, one run having gone 3,000 hours.

A typical electrolysis is that of acetic acid. One mole of acetic acid yields, on electroylsis in anhydrous HF, 0.3 mole CF_3COF, 0.4 mole CF_4, 0.3 mole CF_3H, and very small amounts of OF_2, COF_2, and H_2. Most of the electrolyses have a high hydrogen efficiency. Besides acids and hydrocarbons, both amines and ethers have been fluorinated successfully by this method.

The general behavior of saturated fluocarbons suggests that the electronic structure is similar to that of the rare gases; that is, the outermost electrons are very tightly bound. The fluocarbons are very stable toward oxidation and attack by other chemical agents. In those cases where all the C—H bonds have been replaced by C—F bonds, the compounds are nontoxic with respect to the fluorine content.

Comparison of the boiling-point curves of the fluocarbons which contain some hydrogen with the curves for the corresponding hydrocarbons indicate a marked tendency for hydrogen bonding. The surface tension of fluocarbons are uniformly lower than for the same hydrocarbon. The addition of a fluocarbon to water will change the surface tension, and the maximum change is achieved at very low concentrations. Fluocarbons have a higher temperature coefficient of density than do the hydrocarbons, and the refractive indexes are lower.

Those fluocarbons which are immiscible with water are difficult to emulsify, since the ordinary emulsifying agents do not lower the interfacial tension between water and the fluocarbon below about 5 dynes per cm.

Analysis of the fluocarbons is troublesome, because of the difficulty in getting a complete fluorine recovery. Analysis for purity is made chiefly by means of infrared absorption.

Commenting on the commercial future of the compounds, Dr. Scholberg indicated that water and ordinary greases do not wet certain highly polymerized fluocarbons (e.g., Teflon). This property suggests that cloth made from fibers of such polymers might have the very desirable characteristics of being resistant to dirtying, and of holding a crease permanently—an engaging speculation.

A question period followed the talk, and Dr. Scholberg received a rising vote of thanks for his address.

J. F. HAZEL, *Secretary*

Washington-Baltimore Section

Jeanne Burbank of the Chemistry Division, Naval Research Laboratory, Washington, D. C., gave a very interesting talk on "Phosphate Coatings on Steel" at the January 18th meeting of the Washington-Baltimore Section. The meeting was held at the National Bureau of Standards.

In her talk Miss Burbank gave a brief historical background of the use of phosphate coatings and the role they play in our present-day methods of protecting metals from corrosion. She stated that since the present methods of phosphating require careful control of bath solutions and operating conditions, it is rather difficult to adapt such methods to the coating of large structures. For this reason a study has been directed toward the fundamentals of present-day phosphating in order to obtain a better understanding of the mechanism of the deposition of these coatings with a view to ultimately developing a satisfactory process for use on the larger types of structures.

As an initial phase of the experimental work, the solution rate of steel in phosphoric acid was measured in a series of experiments to determine how this rate is affected by differences in the controlling factors such as reaction time, acid concentration, and temperature. The speaker illustrated this portion of her talk by means of a number of slides. The results of this phase of the work may be summarized as follows: the reaction rate is essentially constant throughout the experimental period of thirty minutes, is directly proportional to the logarithm of the acid concentration, and is an exponential function of the absolute temperature. This information will be useful for comparing these rates with those obtained with commercial phosphating solutions as well as any possible phosphating compounds which may be developed in future work.

Miss Burbank said that while several different phosphates have been reported in the literature there is little x-ray diffraction data to aid in their identification. It is known, however, that phosphating baths change in composition during use and this results in a change in the chemical composition of the coatings as well as their corrosion resistances, but little is known concern-

ing any possible accompanying change in the crystal structure of the coating. Since x-ray diffraction patterns of the compounds involved are rather limited an effort was made to prepare the various phosphates which are likely to be encountered and their diffraction patterns recorded. Photomicrographs of a number of these preparations were shown. As a result of this effort ten new x-ray diffraction patterns were established and can be used as a working file for future investigation of phosphate compounds and coatings.

X-ray diffraction examination of the coatings obtained from zinc and manganese phosphating baths substantiated the work of Durer and Schmidt who claimed that the coatings were tertiary zinc phosphate tetrahydrate and di-tri manganous phosphate, respectively.

As a preliminary effort to apply these findings to larger structures at room temperatures, a zinc phosphate bath was incorporated in an agar gel medium and the mixture applied to a freshly sandblasted steel plate. This mixture was allowed to stand overnight. The same bath was used without a gel to phosphate a second plate in the usual manner. A slide showed that there was very little difference to be detected between the two plates since in both cases the coatings were fine grained and uniform and their x-ray diffraction patterns indicated that both the coatings were tertiary zinc phosphate. It appears therefore that fine grained, uniform zinc phosphate coatings may be deposited on steel at room temperatures from a viscous medium. This would appear to be a step in the right direction toward obtaining a satisfactory method for phosphating large steel structures.

* * *

At the next meeting of the Washington-Baltimore Section Dr. George W. Vinal, "Dean of Batteries in the U. S. A.," will speak on the history of batteries in this country and their development into the present forms. This meeting will be held at 8:00 P.M. on March 15, 1951, in the fourth floor lecture room of the East Building of the National Bureau of Standards.

J. C. White, *Secretary-Treasurer*

Chemical Translations
by mail
Werner Jacobson, B.S., M.S.
Translator and Chemist
Microfilms Accepted
German, Swedish, Danish-Norwegian, French, Spanish, Portuguese, Italian, Russian, Polish, Chinese.
334 South Mozart Street Chicago 12

PERSONALS

Charles H. Moore has been appointed assistant to the technical director, Titanium Division, National Lead Company, South Amboy, New Jersey. During the past year Dr. Moore had been engaged in special projects in the office of the Research Director of National Lead Company in New York City.

Frederick E. Herstein has joined Glascote Products Incorporated, Cleveland, Ohio, as its sales representative in northern New Jersey and parts of New York state. Mr. Herstein has been active in the corrosion resistant chemical equipment field, having served several large firms in development production and design capacities.

Karl Schumpelt has joined the staff of the Forstner Chain Corporation, Irvington, New Jersey. Dr. Schumpelt was formerly with Baker Company Incorporated of Newark, New Jersey.

Frank L. LaQue, Business Manager for the Journal, has been nominated by the American Society for Testing Materials to give the Edgar Marburg Lecture at the annual meeting in June at Atlantic City. The topic of Mr. LaQue's lecture will be "Corrosion Testing."

Gustav Szekely, research chemist at Sylvania Electric Products Incorporated, Flushing, New York, is on a leave of absence from the company to study at the University of Vienna, Vienna, Austria.

John R. Musgrave and Herman Froelich have been appointed to the membership committee of the Society, Dr. Musgrave to represent the Rare Metals Division and Dr. Froelich the Luminescence Division.

C. C. Rose of Willard Storage Battery Company, Cleveland, Ohio, has been appointed as the Society's representative on the American Standards Association Committee C-42.

R. E. McNulty has been named manager of The Dow Company's new magnesium rolling mill at Madison, Illinois. Mr. McNulty was formerly production manager of the magnesium division at Midland, Michigan. The new mill, which will cost about $26,000,000 will produce magnesium coil, plate, extrusions and alloy ingot, billets, and rolling slabs.

Walter J. Manson has been elected vice-president of Kenmore Metals Corporation, Jersey City, New Jersey. Mr. Manson had been plant manager and chief engineer at Kenmore.

DAVID S. NANTZ

David S. Nantz, General Manager of National Distillers Chemical Corporation, Ashtabula, Ohio, died suddenly December 21, 1950, of a heart attack, at the age of 49.

A native of Kentucky, Mr. Nantz was graduated from the University of Kentucky in 1924. He joined the Du Pont Company in Niagara Falls in 1929 and later was in charge of all sodium production at the Electro-Chemicals Division Plant. He then assisted National Distillers in organizing and constructing the Ashtabula plant of which he became manager in 1949.

He was a member of The Electrochemical Society since 1945.

JOSEPH LEEMANS

Joseph Leemans, Vice-President and Administrator of the Société Générale Métallurgique de Hoboken, Belgium, died on January 10th, at Anvers, Belgium. He was 74 years old. Monsieur Leemans was active for many years in scientific organizations in Europe and had been a member of The Electrochemical Society since 1924.

NEW MEMBERS

In January 1951 the following were elected to membership in The Electrochemical Society:

Active Members

Marshall B. Alpert, Research Laboratory, National Lead Company, Titanium Division, P.O. Box 58, South Amboy, New Jersey (Electrodeposition, Industrial Electrolytic, and Theoretical Electrochemistry)

Michael Borushko, Harding Manufacturing Company, 10600 Gratiot Avenue, Detroit 13, Michigan (Electrodeposition)

Howard Y. Clymer, Foote Mineral Company, mailing add: 318 Park Avenue, Swarthmore, Pennsylvania

Clarence K. Conrad, The American Metal Company, Ltd., 61 Broadway, New York 6, New York (Industrial Electrolytic)

Michael J. Ford, American Electro

Metal Corporation, mailing add: 501 W. 110th Street, New York, New York (Corrosion)

JOHN H. GORMAN, Scientific Control Laboratory, mailing add: 600 S. Blue Island Avenue, Chicago, Illinois (Electrodeposition)

JAY C. HARRIS, Monsanto Chemical Company, mailing add: 257 Telford Avenue, Dayton 9, Ohio (Electrodeposition)

RALPH J. HOVEY, JR., Scientific Control Laboratory, mailing add: R.R. 2, Box 484-B, Lombard, Illinois (Electrodeposition)

SRINIVASARAO KRISHNAMURTHY, Indian Telephone Industries Ltd., mailing add: 543/1 17th Cross Road, Malleswaram, P.O. Bangalore 3, India (Electrodeposition)

HENRY S. MIRROW, Motorola Inc., mailing add: 2872 N. Drake Avenue, Chicago 18, Illinois (Electrodeposition)

KIYOKADO NISHIHARA, Kyoto University, mailing add: No. 24, Kitashirakawa Hiraicho Sakyodu, Kyoto, Japan (Electrodeposition and Industrial Electrolytic)

GEORGE STERN, American Electro Metal Corporation, 320 Yonkers Avenue, Yonkers 2, New York (Electrothermic)

HARRY E. STOPEK, Kraft Chemical Company, mailing add: 1439 S. Ashbel, Berkeley, Illinois (Electrodeposition)

G. ROBERT VAN HOUTEN, RCA Victor Division, mailing add: 6165A Carvel Avenue, Indianapolis 20, Indiana (Electrodeposition)

ROBERT D. WILLIAMS, Aluminum Research Laboratories, New Kensington, Pennsylvania (Corrosion and Theoretical Electrochemistry)

Associate Member

WILLIAM G. FORREST, North American Cyanamid Ltd., 1 Forth Avenue, Niagara Falls, Ontario, Canada (Electrothermic)

FUTURE MEETINGS OF OTHER ORGANIZATIONS

AMERICAN SOCIETY FOR TESTING MATERIALS, spring meeting and committee week, Cincinnati, Ohio, March 5–9.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, seventh annual conference and exhibition, Statler Hotel, New York City, March 13–16.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, spring meeting, Hotel Biltmore, Atlanta, Georgia, April 2–6.

GREATER NEW YORK SAFETY COUNCIL, 21st annual safety convention and exposition, Hotel Statler, New York City, April 3–6.

NATIONAL FIRE PROTECTION ASSOCIATION, annual meeting, Hotel Statler, Detroit, Michigan, May 7–11.

EDISON ELECTRIC INSTITUTE, 19th annual convention, Denver, Colorado, June 4–7.

LETTER TO THE EDITOR

International Committee Holds Second Meeting

Dear Sir:

The International Committee of Electrochemical Thermodynamics and Kinetics, created at a meeting held at the University of Brussels, Belgium, in March 1949, held a second meeting at Pallanza, Varenna, and Milan, Italy, on September 18 to 21, 1950. Professor R. Piontelli of the Milan Politecnico and his assistants did a beautiful job of organization contributing considerable time and effort. Financial help was received from one French and several Italian electrochemical firms. The Committee is also indebted to the Directors of the De Marchi Hydrobiological Institute for putting at its disposal the sumptuous Villa Monastero at Varenna on Lake Como and to the authorities of the Milan Politecnico where the last sessions of the meeting were held. The participants, several of them accompanied by their wives, came from eleven countries.

The first gathering took place at a tea on Sunday afternoon, September 17th, on the terrace of the Albergo Maestoso overlooking Lake Maggiore at Pallanza. On Monday, reports by the President and the Secretary were presented and a general session on electrochemical equilibria took place. It was devoted largely to the presentation of potential-*p*H diagrams by M. Pourbaix of Brussels (in collaboration with P. Delahay of Baton Rouge, La., and P. Van Rysselberghe of Eugene, Ore.). G. Valensi of Poitiers, France, presented diagrams for sulfur, a rather complicated case which the diagrams considerably clarify, and A. Juliard of Brussels presented a contribution toward the experimental verification of potential-*p*H diagrams. In the afternoon the group was taken by bus to various hotels at Bellagio on Lake Como.

Four sessions were held on the 19th and 20th at the Villa Monastero at Varenna, the participants being taken there and back each time by motor launches. The beautiful surroundings, far from distracting members from their work, contributed to making the meetings particularly efficient and interesting. The four sessions were devoted to the following topics: electrochemical kinetics, applications to corrosion, applications to general and analytical chemistry, and polarography. The first group of papers was introduced with general remarks by Piontelli who, in addition, presented either alone or with his collaborators, G. Poli and G. Guerci, a series of papers on the important work carried out in Milan. There were again communications by Pourbaix, Juliard, Delahay, and Van Rysselberghe. H. Fischer of Berlin gave an important paper on the influence of inhibitors on electrode kinetics.

The group of papers on corrosion was introduced by some general remarks by T. P. Hoar of Cambridge, England. F. E. W. Wetmore of Toronto, Canada, spoke on the activities of the Associate Committee on Corrosion Research and Prevention, of the National Research Council of Canada. M. Rius and A. S. Terol of Madrid, Spain, gave an interesting account of their experimental work on the relationship between potential and passivity. There were also communications by L. Cavallaro and A. Indelli of Ferrara, Italy, on inhibitors; by Pourbaix on the applications of potential-*p*H diagrams to corrosion, and on electrochemical methods for the removal of incrustations; by F. Tödt of Berlin on the measurement of oxide deposition, hydrogen ion discharge, and concentration of oxygen by cathodic current determinations; and by L. Meunier of Mons, Belgium, on the electropolishing of copper.

The general and analytical chemistry group was introduced by remarks sent by G. Charlot of Paris. In the absence of Charlot, the communication was read and discussed by Valensi. This and two reports by R. Gauguin of Paris on irreversible electrochemical systems and on potentiometric and amperometric methods brought up the complex subject of definitions and nomenclature, which was continued at the last session in Milan. Juliard and L. Gierst of Brussels presented their work on the use of the radial oscillograph in analytical applications. The session on

polarography was introduced by a brief discussion by Wetmore who also presented a paper on a detailed verification of the Ilkovic equation. There were papers by G. Sartori of Trieste on the polarographic behavior of the SH group, by Rius on the deposition of iron on mercury veins, by Gierst and Juliard on technical improvements in polarography, by H. J. Antweiler of Bonn, Germany, on polarographic maximums, by Delahay on oscillographic polarography, and by Van Rysselberghe on percarbonic acid.

On the evening of September 20th the group was taken by bus to Milan where, the following day, two long sessions were held on electrochemical fundamentals, definitions, and nomenclature, and also on the business of the committee particularly in connection with a first project on Rules. The theoretical session was opened with comments by Van Rysselberghe. E. Lange of Erlangen, Germany, and Piontelli presented extensive reports on the fundamentals of electrochemistry. Pourbaix presented descriptions of lecture experiments illustrating electrochemical principles and Piontelli, with G. Bianchi of Milan, gave a report on their critical studies of the use of the Haber-Luggin capillary in potential measurements.

Electrochemical fundamentals was then the subject of a general discussion, and the drawing up of conclusions, recommendations, etc., was entrusted to a subcommittee composed of J. O'M. Bockris (London), R. Defay (Brussels), Lange, Piontelli, and Van Rysselberghe. This subcommittee met at the Milan Politecnico on September 22nd and is continuing its work by correspondence. Its first goal is the preparation of a questionnaire which will be widely circulated among electrochemists and on which a report will be presented at the third meeting of the Committee in the summer of 1951. On one point general agreement was reached without difficulty and a recommendation can be stated as follows:

The International Committee of Electrochemical Thermodynamics and Kinetics most categorically recommends to all electrochemists, physical chemists, physicists, engineers, etc., the exclusive use of standard electrode potentials based upon the so-called European convention, called also (but incorrectly) "reduction potentials." These potentials are, except for an undetermined additional constant, the differences of electric potential between electrodes and solutions in contact. Noble potentials are thus positive and the positive pole of a cell is that which has the higher potential. The Committee, however, will eventually make recommendations concerning the use of the term "potential" which electrochemists employ in a manner very different from the meaning given to this term by physicists, electrical engineers, etc.

Most of the communications led to lively discussions which will be printed with the papers in a volume of Proceedings to be published by the Tamburini firm of Milan.

Besides the Committee members and a few visitors and observers (mostly representatives of Italian government agencies and of industrial firms), the total attendance at the meeting was about sixty persons.

P. Van Rysselberghe
Milan, Italy

BOOK REVIEWS

Economic Aspects of Atomic Power by Sam H. Schurr and Jacob Marschak. Published by the Princeton University Press, Princeton, N. J., 1950. xxvi plus 289 pages, $6.00.

Nuclear Power—a solution in search of a problem

The publication of a book concerned with the economic aspects of nuclear power should be welcomed by everyone concerned with engineering, sociological, or scientific trends in our so-called "atomic age." The prediction of things to come requires and delights a vigorous imagination. Probably never before has there been such a challenging new development—the release per atom of 200 million electron volts of energy compared with the meager 10 electron volts of energy per molecule in a chemical reaction. How will a cool factor of 20 million in energy release affect society?

The authors announce at the start that they will not discuss the effects, on property or life, of releasing this energy for destructive purposes. They carefully set out to study those potential uses of atomic power which "seem least remote today," for example, the generation of electricity from the heat of nuclear reactors, and the transportation of low temperature heat over short distances. In particular, the authors study various industries: aluminum, chlorine and caustic soda, phosphate fertilizer, cement, brick, flat glass, iron and steel, railroad transportation, and residential heating. These industries have been very carefully examined, and the source material has been well summarized. Their investigations are thorough and scholarly. For instance, in addition to a table of contents, there is also an analytical table of contents. In citing more than 250 published papers or books, the authors not only present a valuable reference list, but also take a precaution which is indispensible to a discussion of a subject which is hedged about with secrecy restrictions. Indeed, it is clear that the authors know more than they can say. Their work is carefully organized, well presented, and detailed, and their lack of pretension is often disarming. For instance, in the preface, Dr. Marschak says: "Thus the study is exploratory in a double sense. First, technological data which include future trends in the techniques of generating and using energy are incomplete. One has to use a hypothetical range instead of a single figure. . . .

"Second, the book is exploratory also in the sense that it involves a new attempt to formulate an economic theory of the effects of an invention."

A quick summary of the findings is about as follows: let's assume that we can use as nuclear fuel both U^{238} and U^{235}, even though at present we can only use the less abundant (1 part in 140) U^{235}. The cost of nuclear fuel is then trivial, even compared to the cost of coal. But, in any industry, all of the other costs are very great compared with fuel cost, and the cost of the reactor is very uncertain; therefore, the possibility that the use of nuclear power will affect any industry is very small.

Now, one may ask why almost 300 pages were used to say so little. It would seem that the authors' exploratory work can be described by saying that they should have looked at a forest and they looked at the trees—and they studied the branches and the roots and the bark and the leaves—and made a fine theory of tree growth. But they never saw the forest.

This reviewer enjoyed the book and found it extremely informative. Its fault lies in this: it is difficult, without rather extensive reading of details, to find simple statements of conclusions appropriate to the several possible industrial uses. On page 222 we find the following:

"In most of the other industries studied in Part Two, atomic power, if cheap enough, might induce changes in either process and/or location, as follows:

(1) Aluminum: Change in location, but not in process.

(2) Phosphate fertilizer: Change in process, but probably not in location. Here an energy-intensive process based on electricity would be substituted for a process using only small amounts of energy per ton.

(3) Cement, brick, and flat glass: Changes in process, but probably not in location. In these industries one energy-intensive process would substitute for another—electrically-fired for gas-fired furnaces in glass, kilns heated by hot reactor gas for kilns fired by conventional fuels in cement and brick.

(4) Residential heating: Change in process. Energy previously provided by individual home furnaces would be supplied by a central heating system using nuclear reactors.

(5) Iron and steel: Changes in location and process. Here a process using coke both as a source of heat and as a chemical agent would be replaced by a process using electrolytically-produced hydrogen. The new process would economize on transportation through shipment of sponge iron rather than iron ore.

(6) Railroads: Change in process. Here electric locomotives would substitute for diesel locomotives."

These are only partial conclusions and do not get to the nub of the matter, which is that no one of the industries discussed is at all likely to profit from nuclear power.

Nuclear power needs a salesman—needs one badly—but he must find a real use for the factor of 20 million by which nuclear fission exceeds molecular interaction as an energy source. To degrade this huge factor and then seek an application is the traditional error of those who cannot see beyond their time.

If this work were called "Economic Aspects of Cheap Heat," it would be rightly named and beyond reproach. It seems to a nuclear physicist to be a fine work on industrial engineering, but it does not find the problem for which nuclear power is the solution.

JERROLD R. ZACHARIAS

* * *

THE SOLUBILITY OF NONELECTROLYTES, third edition, by J. H. Hildebrand and R. L. Scott. Published by Reinhold Publishing Company, New York, 1950. 488 pages, $10.

A reader familiar with earlier editions of this book will easily see that a thorough revision has been made. The book represents a very successful attempt to unify the concepts of solubility theory as applied to liquid solution of high polymers and of gases, and solid solutions of metals as well as to the more usual organic mixtures of solids and liquids. The discussion, although to a large extent mathematical, has been reduced to a concise critical presentation in which the main concepts stand out clearly rather than being buried in a mass of details. The reader who ordinarily avoids mathematics will find the exposition a model of clarity and readability. At every step the authors have included a liberal supply of examples to illustrate their points. Unfortunately, even though one realizes that the book is obviously not a mere source book, the reader is sometimes left to wonder whether the examples represent all of the known situations or only a select few.

There are a number of unusual features such as an appendix which includes a worthwhile review article (1949) by the same authors and a compilation of the papers of both authors on the subject of solubility. The book also contains a handy formula index in addition to the usual subject and author indexes.

On the unfavorable side, the reviewer found a number of minor but distracting typographical errors, climaxed on pages 306 and 307 by a complete scrambling of titles for three of the figures. Occasionally, illustrations such as those on page 30 are inadequately labeled, thereby making it difficult for the reader to interpret the graphs even after referring to the text. With the exception of the table of contents, the printing was not uniform, so that many letters were imperfectly formed. Despite these shortcomings, the book will be a valuable addition to the library of a student of physical chemistry whether he be in a university or in industry.

L. B. ROGERS

* * *

AN INTRODUCTION TO LUMINESCENCE OF SOLIDS by H. W. Leverenz. John Wiley & Sons, Inc., New York, 1950. XV and 569 pages, $12.00.

The last of several recent books on the subject of luminescence, this treatise by Leverenz represents the most ambitious and studious effort to date among the discussions that are devoted to the luminescence of solid crystal phosphors. Reminiscent in style and general organization of typical German textbooks, the book is characterized by its attempt at precise and thorough, even dogmatic, presentation of the material. Thus, at times, reading is made harder than the subject seems to warrant, and one wonders whether the book will prove to be really stimulating and inspiring to a novice in the field.

The book starts *ab origine*, with a recapitulation of some pertinent physical, chemical, and crystallographical fundamentals. These are presented not merely as a review, but for the purpose of defining concepts to which the author adheres throughout the text. Succeeding chapters deal in great detail with the preparation, constitution, and structure of phosphors, with the disposition of energy in luminescent systems, and with general properties and technological applications of phosphors. Several appendices and a comprehensive bibliography conclude the book.

No phase of work or thought in regard to crystal phosphors has been overlooked, although the relative emphasis is presented strongly as seen through the author's own background, judgment, or inclination. In the discussion of unsettled questions or disputed material the author tends to present a point of view as favored by him, but in a form as though it were commonly accepted. This, of course, has also been characteristic of other recent books on the subject. The personal and individualistic orientation testifies to the youth of the science of luminescence. However, it also presages the necessity for a textbook, to be written perhaps ten or twenty years hence, which at that time can present the subject from a less partial point of view.

The vast preponderance and importance given to the zinc sulfides appear somewhat out of proportion in relation to other and equally weighty phosphor systems. Much of the sulfide material presented is technological rather than fundamental, or is not balanced by information on different systems. From a scientific point of view, subjects such as alkali halides and the stimulation and the sensitization of fluorescence have, by comparison, received rather scanty treatment. Yet most of the information was available at the time the book went to press. In view of the author's quest for precision of language, one can not quite reconcile his constant mockery of the term "fluorescent lamp" with his sanction of similar half-breed or incorrect expressions such as "television" or "purification of zinc sulfide."

The extensive bibliography is of value only in reference to the text or to the appended table of phosphors, as many important papers are often buried under single numbers and no real systematization was attempted.

The external makeup of the book, the quality of paper and print, of the numerous figures, of proofreading, etc.,

are all excellent. The price can be considered as moderate.

The remarks made above should not in the least detract from the fact that, on the whole, this is a valuable and an important book, the first truly comprehensive effort to present the new science of crystal luminescence from all its different and pertinent aspects.

H. C. FROELICH

* * *

ELECTRICAL ENGINEERS' HANDBOOK, VOL. 2—ELECTRIC COMMUNICATION AND ELECTRONICS, fourth edition, edited by Harold Pender and Knox McIlwain. Published by John Wiley & Sons, Inc., New York, and Chapman & Hall, Ltd., London, 1950. 1618 pages, $8.50.

This handbook is the result of intensive efforts to bring up to date the information relating to a field that has seen tremendous advances in the 14 years since the third edition was issued. The 23 sections of the fourth edition compare with 17 in the previous issue but only two sections are entirely new; the others derive from divisions of subjects and indicate fields where major growth and development have occurred. A complete list of the sections will best serve to show the scope of this handbook.

Mathematics, Units and Symbols
Properties of Materials
Resistors, Inductors, and Capacitors
Electron Tubes
Electric Circuits, Lines, and Fields
Passive Circuit Elements
Vacuum Tube Circuit Elements
Frequency Modulation
Pulse Techniques
Transmission Circuits
Electrical Measurements
Acoustics
Electromechanical Acoustic Devices
Optics
Electro-Optical Devices
Sound Reproduction Systems
Telephony
Telegraphy
Facsimile Transmission and Reception
Television
Electronic Control Equipment Aids to Navigation
Medical Applications of Electricity

Size of print and thickness of paper appear to be close to the minimum for legibility and future revisions may well require serious consideration as to whether there should be a further increase in page size or a further split-up of subjects in separate books. The new edition comprises 1278 pages compared to 842 for the third edition in spite of the editors' efforts at "careful selection and compression." The danger exists that curtailments and omissions may reduce the effectiveness of a handbook that is restricted to particular fields and the Wiley Engineering Handbook Series does not provide the complete answer because there are no gross references between volumes nor any provisions for their simultaneous reissue.

It is a major achievement to gather in and edit the writings of such a long list of eminent authorities (78 in all) and the fourth edition will no doubt be welcomed as a long overdue volume that will enjoy an even greater reputation than heretofore. That one will look in vain for any mention of the transistor* and will find printed circuits referred to only under resistors is simply an indication of the rapid development that has been taking place and emphasizes the need for more frequent revisions of this handbook.

J. H. BOWER

* *Bell System Tech. J.*, **28**: 335–489 (July, 1949).

RECENT PATENTS

Selected for electrochemists by Fred W. Dodson, Chairman of the Patent Committee, from the Official Gazette.

November 14, 1950

Murphy, M. J., 2,529,511, Deferred Action Battery

Lowe, S. P., Long, G. W., Downes, K. W., and Kent, G. H., 2,529,700, Method of Electrolytically Producing Zinc of High Purity

Smith, A. L. J., 2,529,711, Method of Making a Zinc Oxide Phosphor

Gonze, M., 2,529,803, Photochemical Preparation of γ Benzene Hexachloride

Sommer, A., 2,529,888, Electron Discharge Device

Woodyard, J. R., 2,530,110, Nonlinear Circuit Device Utilizing Germanium

Yeater, M. L., 2,530,111, Method and Means for Indicating Ionization Pressure

Levy, H. R., 2,530,204, Electric Lamp

Malek, S. K., 2,530,254, Thermopile Construction

Malek, S. K., 2,530,255, Thermoelectric Generator

Malek, S. K., 2,530,256, Thermoelectric Generator

November 21, 1950

Robinson, H. A., and Grebe, J. J., Application 725,983, Ribbon Anodes in Galvanic Protection of Metals

Gray, A. G., 2,530,366, Electrophoretic Deposition of Ethylene Polymers

Lowry, E. F., Mager, E. L., and Keilholtz, G. W., 2,530,394, Electrode Coating for Discharge Devices

Hlavin, W. S., 2,530,524, Liquid Treating Device

Raney, R. M., and Jones, V. J., 2,530,539, Storage Battery

Snyder, J. M., 2,530,546, Electrophoretic Deposition of Insulating Coating

Stoddard, W. B. Jr., 2,530,552, Soldering Method for Positioning Strip Material

Berkenkotter, E. L., and Herz, J. H., 2,530,677, Apparatus for Plating Crankshafts

Humphrey, E. L., and Mitchell, E., 2,530,699, Photochemical Chlorination of Hydrocarbons

Anderson, E. L., and Anderson, L. B., 2,530,751, Primary Cell

Ruggieri, E. P., 2,530,842, Manufacture of Metal to Metal Duplications

Gibney, R. B., 2,530,956, Electrographic Recording

Jernstedt, G. W., 2,530,967, Bright Alloy Plating

Phillips, F. J., 2,531,154, Process for Producing Stainless Steel Immune to Intercrystalline Corrosion

Phillips, F. J., 2,531,155, Stainless Steel

Rutherford, H. E., 2,531,162, Battery Connector

Olson, C. A., 2,531,291, Battery Connector

Thomas, W. S., 2,531,307, Battery Terminal Connector

Thomas, W. S., 2,531,308, Method for Making Battery Terminal Connectors

Thomas, W. S., 2,531,309, Terminal Connector

Lowry, E. F., and Homer, H. H., 2,531,339, Method of Preparing Electron-Emissive Coating Materials

November 28, 1950

Salazar, A. M., 2,531,472, Battery Charger

Witten, B., 2,531,487, Electrolytic Production of Cacodyl

Dillehay, E. R., and Schuetz, R. D., 2,531,504, Separator for Electric Storage Batteries

Sheppard, E. A., and Glover, B. W., 2,531,535, Manufacture of Alternating Electric Current Rectifiers

Crochet, P., and Lambert, R. E., 2,531,612, Method for Melting Glass by Electricity

Stearn, R. F., 2,531,747, Metal Identifier

Hensel, F. R., and Larsen, E. I., 2,531,910, Aluminum Thallium Bearing

Bean, D. R., 2,531,964, Electric Metallurgical Apparatus

Dubilier, W., 2,532,016, Electrical Liquid Treating Device

Newell, H. D., 2,532,117, Nickel Steel Alloys

Stevenson, W. N., 2,532,127, Battery Post Gripping Head for Electric Cables

December 5, 1950

Batcheller, C., 2,532,389, Metal Coating Device

Schneider, M. S., 2,532,516, Electroplating Rack

Simpson, D. M., 2,532,520, Nonoverfill Indicator for Battery Cells

Konrad, E. H., and Eustis, W. E. C., 2,532,629, Method of Electrodepositing Iron

Kröger, F. A., and Broos, J., 2,532,774, Magnesium Silicate Titanate Phosphor

Hangosky, C. W., 2,532,907, Method and Apparatus for Electrolytically Treating Metal Surfaces

Hangosky, C. W., and Hornberger, C. S., 2,532,908, Electrolytic Processing Apparatus

Hopkins, R. K., 2,532,914, Apparatus for Producing Alloy Ingots

Cudd, H. H., and Freeman, E. J., 2,533,096, Production of Iron Powder

December 12, 1950

Eastman, E. D., deceased, by Eastman, A. G., executrix, Application 3,507, Electrodeposition of Uranium

Allan, B. W., and Rummery, F. O., 2,533,208, Electrolytic Production of Gelatinous Titanium Hydrate Nuclei

McLean, W. S., 2,533,387, Method and Apparatus for Making Dynodes

Ingram, M., 2,533,462, Electrode Assembly

Jasper, J. W., 2,533,464, Rack for Supporting Flat Metal Sheets in Electroplating Operations

Stoddard, W. B. Jr., 2,533,532, Electrodeposition of Nickel

Stoddard, W. B. Jr., 2,533,533, Method of Forming a Strongly Adherent Electrodeposit

Lohr, J. M., 2,533,735, Electric Resistance Element and Method of Heat-Treatment

Let BURGESS Solve Your Battery Problems!

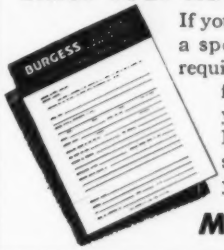
Leader in Electrochemical Research

Burgess is a pioneer in the field of Electrochemical research. For more than 30 years Burgess engineers have led in special battery development and manufacture. The complete Burgess facility . . . engineering . . . design . . . production . . . is available to provide the exact dry battery for any particular application.

Hundreds of Battery Types Already Available

You may find the exact battery for your special requirements among the hundreds of types already developed by Burgess engineers. Standard and special types are handled by Burgess distributors everywhere, thus simplifying replacement battery problems for users of your equipment.

Enter Your Requirements with Us!



If you are in the design stage and need a special battery to meet special requirements, mail the coupon below for a FREE check-sheet to enter your battery specifications with Burgess engineers. They will then send you complete information on your special battery.

MAIL COUPON TODAY!

Burgess Battery Company
Dept. ECS, Freeport, Ill.

Please send, without cost or obligation a Burgess check-sheet for entering our dry battery specifications.

Name.....*Title*.....

Firm Name.....

Address.....

City.....*Zone*.....*State*.....

NOTES FROM INDUSTRY

Products

RUTHERFORD INSTRUMENT COMPANY, Washington, D. C., offers the Polaro-Analyzer, an instrument for rapid, automatic inked-chart recording of polarograms that gives results as precise as the manual method and that uses a recorder having a pen speed twice as fast as other recorders. According to the manufacturer, it is simple to operate and has numerous recent improvements which make it the fastest and most versatile in the field.

YARDNEY ELECTRIC CORPORATION, 105 Chambers Street, New York City, has added Model No. 5 HR to its line of Yardney Silvercel storage batteries. Model No. 5 HR is described as about one fourth the weight and one third the

volume of a standard lead-acid battery of the same capacity (3 inches high, weighs 4.3 ounces). It is spillproof, shockproof, and capable of high-rate discharges. Operation is uniform and it can be used at very high altitudes. Suitable for photoflash equipment, portable instruments, etc.

ALLIED RESEARCH PRODUCTS, INCORPORATED, Baltimore, Maryland, has expanded its line of plating brighteners for use on zinc and cadmium. All are adaptable to any type of electroplating equipment and offer the following advantages: better throwing power, increased solution efficiency, uniform coverage, and higher quality work.

For zinc plating, ARP #5 is adapted to low current density ranges and produces a bright plate with a blue chrome-type cast. ARP #3 is for higher current densities and produces a zinc plate with a bright yellow nickel-type cast. ARP #4, for cadmium, operates throughout any current density and produces a silvery bright plate.

Publications

PRUFCOAT LABORATORIES, INCORPORATED, 63 Main Street, Cambridge, Massachusetts, will send on request Technical Bulletin 012 describing their new product, Prufcoat Metal Reactive Primer P-10. The new coating provides a simple, two-step system for corrosion-proofing old or moist metal surfaces.

YEOMANS BROTHERS COMPANY, 1433 North Dayton Street, Chicago, has issued a new condensed catalog listing a full line of pumps for handling corrosive and noncorrosive liquids, solids-carrying liquids, and dry and semi-dry materials. Available upon request on business letterhead.

LEEDS & NORTHRUP COMPANY, 4934 Stenton Avenue, Philadelphia, manufacturer of Electro-Chemograph, Type E, has issued an illustrated 16-page publication—EM9-90(1)—to provide information about polarographic equipment, adaptable to operation from a standard 115-volt a-c supply circuit. Applicability of the method and the instrument is outlined; also a technical section is included about polarographic theory. Copies will be sent upon request.

DETREX CORPORATION, Box 501, Detroit, Michigan, has released a folder, Solvent-Emulsion Cleaners, which describes a series of emulsion cleaners designed to remove both oil-soluble and water-soluble soils from any metal or alloy, without attacking the base metal, and harmless to most paint finishes.

EBERBACH & SON COMPANY, Ann Arbor, Michigan, has available upon request a new 24-page Working Manual showing where and how the Eberbach DYNA-CATH Magnetic Mercury Cathode Apparatus can be employed. Included are performance data, extensive bibliography, operating instructions, etc.

Personalities

VICTOR CHEMICAL WORKS, Chicago, Illinois, has announced the following promotions: Clarence G. Derick to superintendent of operations in Montana, including the phosphorus plant under construction at Silver Bow and the nearby phosphate mines; Charles A. Hendrickson to production superintendent at the new Silver Bow plant; C. J. Stoltenberg to assistant to the general personnel director in Chicago Heights, Illinois.

FRANK BELL has been appointed staff representative for Hycar American rubbers according to an announcement by B. F. Goodrich Chemical Company, Cleveland, Ohio.

EMPLOYMENT SITUATIONS

Please address replies to box shown, % The Electrochemical Society, Inc., 235 West 102nd Street, New York 25, N. Y.

Positions Available

ELECTROCHEMIST, M.S. or Ph.D., with experience mainly in electroplating and electroforming techniques for advanced development in the electron tube industry in southeastern Pennsylvania. *Reply to Box A-220.*

TWO CHEMISTS OR CHEMICAL ENGINEERS in modern laboratory, research division of light metals company. (1) Ph.D. in physical chemistry or electrochemistry for fundamental research and development of metal finishing processes. Some experience in industrial or academic research desirable but not mandatory. (2) B.S. or M.S. chemist, chemical engineer, or metallurgist with several years of practical experience in metal finishing, for process development and technical service work. Please give specific details of education, experience, salary expected, and availability date. All inquiries treated in confidence and considered promptly. *Reply to Box A-221.*

RESEARCH CHEMIST OR METALLURGIST, with experience in the development of processes for production of metals, for work on new methods of producing titanium. Prefer man with M.S. or Ph.D. degree. New England. *Reply to Box A-222.*

NAVAL RESEARCH LABORATORY has announced that it has available several positions of interest to Society members. At present, Civil Service status is not a prerequisite for consideration. A list of the vacancies to be filled may be obtained from the Personnel Division, Code 1817, Naval Research Laboratory, Washington 25, D. C.